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A KEY TO THE SPECIES OF OAKS OF EASTERN NORTH AMERICA BASED ON FOLIAGE AND TWIG CHARACTERS

SARAH C. DYAL

THERE is at present no adequate means for the identification of oaks by their leaves alone, without information concerning the fruit, twigs, bark, and other characteristics not ordinarily available on herbarium specimens. Since poor herbarium specimens and other more or less fragmentary material are constantly coming in for identification it was thought desirable to determine whether a practical key could be devised based on leaf characters only. After much detailed study of all of the various characters connected with the oak leaves such as the type, size, branching, spread, color, abundance, and distribution of the hairs, shape, size, thickness, and color of the leaf, size and shape of the upper epidermal cells, venation on the upper surface of the leaf, the distal angle between the principal veins and the midrib, and the length of the petiole, and after many trials, the appended key was prepared, which on testing has seemed to meet our needs. It is hoped that it may be of use to others faced with similar problems of identification.

The key was intended to include all the species and varieties of oaks occurring east of the Mississippi River but owing to a lack of material *Q. microcarpa* Small and *Q. succulenta* Small were finally omitted.

The material forming the basis of this study was that in the herbarium of Cornell University and some sent in by botanists from various sections of the area covered. After the first draft of the key was made the material at the Gray Herbarium, the Arnold Arboretum, the New York Botanical Garden, the Field Museum, the

University of Minnesota, and the University of Michigan was examined as a check to the results previously obtained.

To render the key more easily usable a few explanatory notes are perhaps in order. Special attention should be called to the two fundamental types of hairs found on oak leaves. The most conspicuous is a non-glandular commonly branched type distributed over the surface of the leaf or confined to the veins or vein axils. This type itself falls into two subtypes, depending on the way in which the branches spread from the hair axis as to whether these branches spread all at one point or above one another. In addition to this non-glandular type there is generally another kind which is usually more minute and less conspicuous. These hairs are generally appressed or occasionally looser, and are usually of a distinctly stellate structure though rarely simple. The cell walls in these hairs are irregular and give a viscid impression as viewed under the microscope though there is little evidence of actual viscosity as indicated by debris attached to them. They have been designated "glandular hairs"¹ by other authors and the term is retained, but they should not be confused with the capitate type of glandular hairs to which the term is usually applied.

While many features of the various hairs may be seen by inspecting the leaf with a hand lens or low power microscope, for accurate study it is desirable to remove some of the hairs to a glass slide where they may be teased apart, covered with a cover glass and observed under higher magnification. For measuring the spread of the hair branches an eye-piece micrometer was used. For measuring the thickness of the leaves a cover-glass micrometer was employed.

1. Non-glandular hairs entirely absent from both surfaces of the leaf when mature. (A form of *Q. lyrata* is entirely glabrous except for a few non-glandular and almost simple hairs scattered along the midrib and veins beneath.) 2.
2. Upper epidermal cells markedly elongated over the smaller veinlets; apex and lobes of leaves rounded or notched, without bristle tips 3.
3. Base of leaf auricled 1. *Q. robur* L.
3. Base of leaf rounded or cuneate 4.
 4. Leaves 5-9-lobed with sinuses $\frac{1}{2}$ or more of the way to the midrib, usually glaucous beneath and usually with minute appressed glandular hairs scattered over the lower surface 2. *Q. alba* L.
 4. Leaves entire or shallowly 3-13-lobed with the sinuses less than $\frac{1}{2}$ of the way to the midrib, or 3-lobed with the sinuses about $\frac{1}{2}$ of the way to the midrib 5.

¹ Engelmann, George. About the Oaks of the United States. Trans. St. Louis Acad. Sci. 3: 372-400. 1868-77 (Repr. "Botanical Works," Ed. Wm. Trelease and Asa Gray. 1887).

5. The leaves 3–13-lobed with sinuses one third or more of the way to the midrib or rarely entire. 3. *Q. austrina* Small.

5. The leaves entire or shallowly 3–5-lobed with the sinuses less than one third of the way to the midrib. 4. *Q. Durandii* Buckl.

2. Upper epidermal cells slightly elongated or isodiametric over the smaller veinlets; apex of leaf acute and usually bristle-tipped. 5. *Q. laurifolia* Michx.

1. Non-glandular hairs present on one or both surfaces of the leaf though often confined to the veins or even vein axils. 6.

6. Leaves with non-glandular hairs distributed over the lower surface or scattered along the midrib and principal veins, rarely in conspicuous tufts in the axils of the veins and then the lower surface densely pubescent. 7.

7. Branches of the non-glandular hairs spreading at the same distance from the surface of the leaf, the hairs loose or appressed; leaves usually without bristle tips. 8. **WHITE OAKS (except No. 26).**

8. Non-glandular hairs sessile or very nearly so, appressed or loose. 9.

9. Leaves entire or shallowly lobed with the sinuses usually less than one third of the way to the midrib. (Sometimes deeply 3-lobed near the middle in No. 3.) 10.

10. Upper epidermal cells markedly elongated over the smaller veinlets. 11.

11. Margin of leaves entire or shallowly 3–5-lobed. 12.

12. The leaves yellowish or grayish brown beneath; glandular hairs usually present; non-glandular hairs scattered over the upper surface or sometimes only on the midrib; glandular and non-glandular hairs present on the petiole. 13.

13. Petioles more than 5 mm. long; leaves shallowly 3–5-lobed; twigs scurfy pubescent. 21. *Q. stellata* Wang., var. *Boyntonii* (Beadle) Sarg.

13. Petioles usually less than 5 mm. long; leaves entire or shallowly 3-lobed toward the apex; twigs nearly smooth. 6. *Q. Chapmanii* Sarg.

12. The leaves silvery white or pale green beneath; glandular hairs absent; upper surface glabrous or sometimes a few non-glandular hairs near the base of the midrib; petioles glabrous or sometimes with a few non-glandular hairs. 14.

14. Leaves silvery white and densely pubescent beneath, or pale green with non-glandular hairs scattered over the entire lower surface; leaves entire or but slightly lobed at the apex. 4. *Q. Durandii* Buckl.

14. Leaves pale green beneath, with non-glandular hairs scattered along the midrib and veins beneath; leaves shallowly 3–5-lobed. 3. *Q. austrina* Small.

11. Margin of leaves coarsely serrate, deeply sinuate-dentate, or crenate-serrate. 15.

15. Non-glandular hairs on the lower surface of the leaf of two sizes mixed (the larger loose, 2-8-branched with a spread of 0.40-0.60 mm., the smaller appressed, (2)-4-8-branched with a spread of 0.15-0.30 mm.); or all large, loose, and 8-15-branched with a spread of 0.20-0.40 mm. . . . 16.
16. Non-glandular hairs on the lower surface of the leaf gray; some of the principal veins ending in the sinuses 7. *Q. bicolor* Willd.
16. Non-glandular hairs on the lower surface of the leaf of two colors, small ones gray and the larger ones yellow; principal veins ending in the lobes 12. *Q. prinoides* Willd., var. *rufescens* Rehder.
15. Non-glandular hairs on the lower surface of the leaf all of about the same size, small, appressed; or if larger, then loose with a spread of 0.20-0.40 mm. and simple or 2-4-(5)-branched 17.
17. Leaves with a pair of sinuses about the middle or below wider and deeper than the others; some of the principal veins often ending in the sinuses . 18. *Q. macrocarpa* (form)
17. Leaves with sinuses essentially uniform; principal veins ending in the lobes 18.
18. Non-glandular hairs on the lower surface of the leaf a mixture of simple, 2-3 or -4-branched hairs, rarely with a few 5-branched hairs mixed with others, the 5-branched hairs when present loose with a spread of more than 0.20 mm. . . . 19.
19. Spread of the non-glandular hairs on the lower surface of the leaf 0.08-0.20 mm., mostly appressed; lower surface of the leaf rough to the touch; minute appressed glandular hairs usually scattered over the lower surface 8. *Q. montana* Willd.
19. Spread of the non-glandular hairs on the lower surface of the leaf 0.20-0.40 mm., loose; lower surface of the leaf soft to the touch; glandular hairs usually absent 9. *Q. Prinoides* L.
18. Non-glandular hairs on the lower surface of the leaf a mixture of 4-12-branched appressed hairs with a spread of usually less than 0.20 mm. . . . 20.
20. Leaves with 8-13 teeth on each side (sometimes small leaves with 6 teeth on each side on the same twig with the large leaves); teeth usually acute. 10. *Q. Muhlenbergii* Engelm.
20. Leaves with 5-8 teeth on each side, teeth usually obtuse 11. *Q. prinoides* Willd.
10. Upper epidermal cells not markedly elongated over the smaller veinlets 21.
21. Non-glandular hairs on the lower surface of the leaf loose, with a spread of 0.20-0.40

mm.; leaves strongly reticulate-venulose on the lower surface 14. *Q. virginiana* Mill., var. *geminata* (Small) Sarg.

21. Non-glandular hairs on the lower surface of the leaf appressed, with a spread of 0.10–0.20 mm.; leaves less strongly reticulate-venulose on the lower surface. (Larger and broader leaves somewhat more reticulate.) 22.

22. Leaves usually entire 13. *Q. virginiana* Mill.

22. Leaves repand-dentate or the upper ones sometimes entire 15. *Q. virginiana* Mill., var. *dentata* (Chapm.) Sarg.

9. Leaves lobed with the sinuses more than one third of the way to the midrib. (If 3-lobed, the lobes above the middle.) 23.

23. Base of leaf auricled 1. *Q. robur* L.

23. Base of leaf rounded or cuneate 24.

24. Petiole pubescent, usually scurfy; non-glandular hairs on the petiole a mixture of 4–8-branched hairs 25.

25. Non-glandular hairs on the lower surface of the leaf of two sizes mixed (the larger loose, 2–8-branched with a spread of 0.30–0.60 mm., the smaller appressed, 4–8-branched with a spread of 0.15–0.30 mm.) 7. *Q. bicolor* Willd.

25. Non-glandular hairs on the lower surface of the leaf all of about the same size 26.

26. Leaves silvery white beneath with appressed non-glandular hairs dense, or scattered over the entire surface; glandular hairs absent or inconspicuous; more than three pairs of principal veins ending in the lobes, others ending in the sinuses 16. *Q. macrocarpa* Michx. and 17. var. *olivaeformis* (Michx. f.) Gray.

26. Leaves tawny beneath with loose non-glandular hairs scattered along the midrib and veins; glandular hairs usually dense beneath giving a yellowish appearance to the surface of the leaf; only two or three pairs of principal veins ending in the lobes 27.

27. Leaves with 5–(7) diverging lobes, the base short-cuneate or rounded 19. *Q. stellata* Wang.

27. Leaves with 3 ascending lobes, the base long-cuneate 20. *Q. stellata* Wang., var. *paludosa* Sarg.

24. Petiole usually glabrous, sometimes with a few simple or 2-branched non-glandular hairs 28.

28. Leaves with glandular hairs absent on the lower surface 29.

29. Lower surface of leaf silvery white; non-glandular hairs usually dense on the lower surface of the leaf 22. *Q. lyrata* Walt.

29. Lower surface of leaf pale green; non-glandular hairs scattered over the lower surface or only on the midrib and veins 23. *Q. lyrata* Walt. f. *viridis* Trel.

28. Leaves with minute appressed glandular hairs scattered over the lower surface 2. *Q. alba* L.

8. Non-glandular hairs distinctly pedicellate (pedicel 4 or more times the width of the hair branch), loose 30.

30. Leaves 3-8-lobed 31.

31. Non-glandular hairs on the lower surface of the leaf all cream colored 24. *Q. stellata* Wang., var. *Margareta* (Ashe) Sarg.

31. Non-glandular hairs along the midrib and veins beneath yellowish, others cream colored 25. *Q. stellata* Wang., var. *arinosa* Sarg.

30. Leaves entire except on vigorous shoots, then toothed 32.

32. Leaves 0.18-0.35 mm. thick with strongly revolute margins and without bristle tips; non-glandular hairs on the lower surface of the leaf of two sizes mixed (the larger, loose, the smaller, appressed) 14. *Q. virginiana* Mill., var. *geminata* (Small) Sarg.

32. Leaves 0.07-0.14 mm. thick, without revolute margins, and with bristle tips; non-glandular hairs on the lower surface of the leaf all of about the same size, usually with a very long pedicel 26. *Q. imbricaria* Michx.

7. Branches of the non-glandular hairs spreading at different distances from the surface of the leaf (the uppermost often forming a whorl, the internodes often suppressed giving a "burr-like" appearance to the hair); leaves usually with bristle tips 33. BLACK OAKS.

33. Leaves entire or slightly lobed on vigorous shoots 34.

34. Ultimate veinlets raised on the upper surface of the leaf; leaves with 9-13 or more pairs of principal veins; tufts of hairs absent in the axils of the veins beneath 27. *Q. pumila* Walt.

34. Ultimate veinlets sunken on the upper surface of the leaf; leaves with 6-9 pairs of principal veins; tufts of brownish hairs sometimes present in the axils of the veins beneath 28. *Q. cinerea* Michx.

33. Leaves lobed 35.

35. Lower surface of leaf usually densely tomentose; glandular hairs when present more or less hidden among the non-glandular hairs 36.

36. Leaves 3-7 (usually 3-5)-lobed the sinuses broad and shallow 37.

37. Lower surface of leaf canescent, base cuneate 29. *Q. ilicifolia* Wang.

37. Lower surface of leaf tawny, base usually rounded 32. *Q. rubra* L., f. *triloba* (Michx.) Ashe.

36. Leaves 3-11 (usually 5-11)-lobed the sinuses broad and deep 38.

38. Leaves with terminal lobe much elongated and all of the lobes more or less falcate; usually tawny beneath 30. *Q. rubra* L.

38. Leaves with all of the lobes about equal, usually not falcate, canescent beneath 31. *Q. rubra* L., var. *pagodaefolia* Ashe.

35. Leaves with scattered pubescence beneath; appressed amber-colored glandular hairs usually present beneath and conspicuous, either over the entire lower surface or along the midrib and veins 33. *Q. velutina* Lam.

6. Leaves with non-glandular hairs in tufts which are in the axes of some or all of the primary veins beneath or extending along the midrib and in some species also scattered over the lower surface. (In some species the tufts are very small, consisting of only a few hairs in some of the primary vein axes.) 39. *BLACK OAKS.*

39. The leaves entire or shallowly 3-5-lobed 40.

40. Leaves markedly dilated upward, usually with hairy petioles 41.

41. Lower surface of leaf yellow-brown or conspicuously yellow-green, scurfy with appressed branched amber-colored glandular hairs; leaves sometimes shallowly 3-5-lobed; base of leaf narrowly rounded or cordate 34. *Q. marilandica* Muench.

41. Lower surface of leaf pale-green but not conspicuously yellow-green; glandular hairs when present not conspicuous; base of leaf cuneate 42.

42. Leaves entire or undulate at the apex 35. *Q. nigra* L.

42. Leaves 3-lobed at the apex 36. *Q. nigra* L., var. *tridentifera* Sarg.

40. Leaves not markedly dilated upward; petiole usually glabrous 43.

43. Upper epidermal cells markedly elongated over the ultimate veinlets 35. *Q. nigra* L.

43. Upper epidermal cells slightly elongated or isodiametric over the ultimate veinlets 44.

44. Leaves with cream- to amber-colored glandular hairs and also sometimes non-glandular hairs scattered over the lower surface; leaves 2-5 cm. long, oval to oblong-obovate, with strongly revolute margins 37. *Q. myrtifolia* Willd.

44. Leaves with glandular hairs absent on the lower surface, non-glandular hairs usually confined to tufts or sometimes scattered along the sides of the midrib beneath; leaves 4-13 cm. long, ovate-lanceolate, elliptic-lanceolate, or rhombic (rarely oblong-obovate), without strongly revolute margins (slightly revolute in *Q. laurifolia*) 45.

45. Leaves ovate-lanceolate, sometimes oblong-obovate with 3-5 coarse teeth toward the apex, somewhat glossy above and dull beneath 38. *Q. phellos* L.

45. Leaves elliptic-lanceolate or rhombic, glossy on both surfaces 46.

46. Leaves yellow-green and elliptic-lanceolate in outline 5. *Q. laurifolia* Michx.

46. Leaves blue-green and rhombic, sometimes broadest above the middle 39. *Q. laurifolia* Michx., var. *rhombica* Trel.

39. The leaves deeply 3-13-lobed or if shallowly lobed with 5-7 lobes 47.

47. Petiole of larger leaves from 0.2-1.5 cm. long 48.

48. Leaves with petioles less than 0.5 cm. long 35. *Q. nigra* L. (form).

48. Leaves with petioles from 0.5-1.5 cm. long 49.

49. The leaves 0.12-0.22 mm. thick, usually faintly lobed, and usually very glossy on the upper surface; midrib broad, one millimeter or more wide at the base, raised on the upper surface 40. *Q. Catesbeai* Michx.

49. The leaves 0.07–0.11 mm. thick, the lobes usually nearly or quite straight, glossy above but not conspicuously so; midrib slender, less than one millimeter wide at the base . . . 41. *Q. georgiana* M. A. Curtis.

47. Petiole of larger leaves from 1.5–7.5 cm. long. (Usually 2–7.5 cm. long) . . . 50.

50. Non-glandular hairs in the axils of the veins beneath a mixture of 10–20-branched hairs . . . 51.

51. Principal leaf lobes or some of them with one or two small bristles on the sides of the lobe less than 5 mm. from the apex; lobes rather blunt . . . 52.

52. Leaves with upper principal pair of sinuses narrow and curving forward, all sinuses usually rounded at the base; principal veins, except the lowest pair, nearly or quite straight, ascending or diverging; bud scales usually gray . . . 42. *Q. Shumardii* Buckl. and 43. *Q. Shumardii* Buckl., var. *Schneckii* (Britton) Sarg.

52. Leaves with upper principal pair of sinuses wide and spreading, some of the sinuses truncate at the base; principal veins usually curved, diverging, lowest pair usually more strongly curved; bud scales reddish brown. . . . 44. *Q. palustris* Muench.

51. Principal leaf lobes without small bristles on the sides of the lobe less than 5 mm. from the apex; lobes usually long-tapering . . . 45. *Q. Nuttallii* E. J. Palmer.

50. Non-glandular hairs in the axils of the veins beneath a mixture of 4–8–(10)-branched hairs . . . 53.

53. Burr-like non-glandular hairs usually scattered over the lower surface or along the midrib in addition to the non-glandular hairs in the tufts in the vein axils; midrib pubescent on the upper surface of the leaf; amber glandular hairs usually present on the lower surface of the leaf, scattered over the surface or only along the midrib and veins; petioles scurfy pubescent all over or only on the upper side, sometimes only near the base, rarely glabrous; buds densely gray tomentose . . . 33. *Q. velutina* Lam.

53. Burr-like non-glandular hairs usually absent on the lower surface of the leaf, when present confined to the tufts in the vein axils; midrib usually glabrous on the upper surface of the leaf; glandular hairs absent; petiole usually glabrous, sometimes with a few scattered non-glandular hairs; buds glabrous or only pubescent above the middle . . . 54.

54. Principal lobes of the leaf usually broadest at the base, tapering toward the apex; length of the lobes less than or equaling the width of the broad middle portion of the leaf (rarely one and one half times the middle portion) . . . 46. *Q. borealis* Michx. f. and 47. *Q. borealis*, var. *maxima* (Marsh.) Ashe.

54. Principal lobes of the leaf broadest at the apex or with the sides nearly or quite parallel; the length of the largest lobes two or more times the width of the narrow middle portion of the leaf . . . 55.

55. Trees of uplands; winter buds red or orange-brown 56.

56. Range from northwestern Indiana to Manitoba, south to northern Missouri; winter buds usually glabrous and shining 48. *Q. ellipsoidalis* E. J. Hill.

56. Range from Maine and southern Ontario to southern Nebraska, southward to North Carolina, Alabama and Arkansas; winter buds usually pubescent toward the tip 49. *Q. coccinea* Muench.

55. Trees of lowlands; winter buds reddish-gray or gray 42. *Q. Shumardii* Buckl. and 43. *Q. Shumardii* Buckl., var. *Schneckii* (Britton) Sarg.

4. *Q. DURANDII* Buckl. Two forms of this species occur, one with leaves green beneath and the other with leaves white-tomentose on the lower surface. Trelease¹ has considered these as mesophytic and xerophytic forms respectively. Dr. E. J. Palmer states that he has found both leaf forms on the same tree which would indicate that the variations are of little ecological or taxonomic importance.

7. *Q. BICOLOR* Willd. Here, as in *Q. Durandii*, two leaf types as to pubescence occur, one green and the other white-tomentose beneath. Trelease has considered these as mesophytic and xerophytic forms with the implication that the first one is a woodland form but this point needs further study. This green form has been designated by Trelease as var. *mollis* Nutt.

8. *Q. MONTANA* Willd. *Q. Prinus* L. of most authors (see Sargent, *RHODORA*, **17**, 40, 1915).

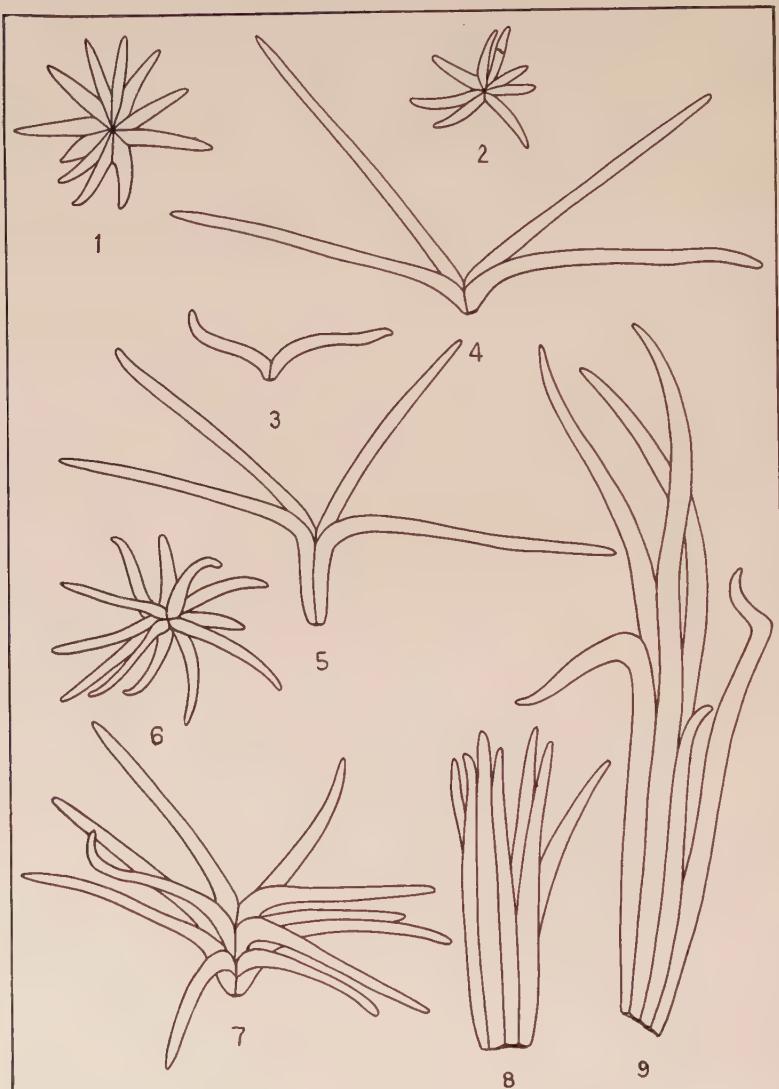
9. *Q. PRINUS* L. *Q. Michauxii* Nutt. of most authors (see Sargent, *RHODORA*, **17**, 40, 1915).

14. *Q. VIRGINIANA* Mill., var. *GEMINATA* (Small) Sarg.² This is recognized as a distinct species by Small and undoubtedly it lies on the border line as to distinctness. The much larger hairs may be added in support of Small's contention, but the general variability of foliage and habit in this species has seemed to indicate the desirability of a conservative point of view at least for the present. A low form with more repand-serrate leaves may be recognized as var. *dentata* (Chapm.) Sarg. The hairs in this variety resemble those of the typical form but tend to have fewer branches. Other leaf forms have been recognized as distinct varieties by Sargent but are of doubtful taxonomic value.

22. *Q. LYRATA* Walt. As in *Q. Durandii* and *Q. bicolor* there is in this species also a green and a whitened leaf form. Whether these are woodland and exposed types as suggested by Trelease should be more fully investigated.

¹ Trelease, Wm. The American Oaks. Mem. Nat. Acad. Sci. **20**: 7 1924.

² Sargent, C. S. Bot. Gaz. **65**: 445, 446, 1918.



NON-GLANDULAR HAIRS OF QUERCUS

WHITE OAK TYPE: FIG. 1, *Q. virginiana* and FIG. 2, *Q. Muhlenbergii*, top view of sessile appressed hair; FIG. 3, *Q. montana* and FIG. 4, *Q. stellata*, side view of sessile hair; FIG. 5, *Q. imbricaria*, side view of pedicellate hair.

BLACK OAK TYPE: FIG. 6, *Q. cinerea*, top view; FIG. 7, *Q. velutina*, side view.

VEIN AXIL TYPE: FIG. 8, *Q. borealis* and FIG. 9, *Q. velutina*, side view.

24. *Q. STELLATA* Wang., var. *MARGARETTA* (Ashe) Sarg. This form has been treated variously, as a species, as a variety and as a possible hybrid of *Q. alba* and *Q. stellata*. In opposition to the latter interpretation may be mentioned the pedicellate hairs which are sessile in both of the supposed parents, and the absence of glandular hairs which are found on the leaves of both parents. Also there is a denser pubescence on the mature leaves than on either *Q. alba* or *Q. stellata*. On the other hand there is little to warrant its recognition as a species. The difference in acorn size emphasized by Small does not seem to exist in our specimens. The variation in leaf shape and in the pedicel of the hair seems scarcely sufficient to constitute a species without other supporting characters.

26. *Q. IMBRICARIA* Michx. This is the only black oak studied having the white oak hair type but it is easily distinguished from the other entire-leaved oaks both black and white by the large pedicellate non-glandular hairs on the lower surface of the leaf.

Three specimens of the so-called *Q. Leana* Nutt. (one from Biltmore, N. C. and two from Ohio) are at hand. *Q. Leana* is usually interpreted as a hybrid of *Q. velutina* and *Q. imbricaria*. These specimens are interesting from the standpoint of hair types with reference to the supposed parentage. When the leaves are young the upper surface is furnished with the "burr-like" hairs of the black oak group (including *Q. velutina*) while the hairs of the lower surface are of the *imbricaria* type. At maturity the upper surface of the leaves has become entirely glabrous but the lower surface is still tomentose with the *imbricaria* type of hair. These hair types seem to support the supposed hybrid parentage.

28. *Q. CINEREA* Michx. The leaves of this species are often confused with those of *Q. virginiana* but the hairs are very different and serve as a good means of identification.

30. *Q. RUBRA* L. *Q. falcata* Michx. of many authors (see Sargent, *RHODORA*, **18**: 45, 1916).

46. *Q. BOREALIS* Michx. f., var. *MAXIMA* (Marsh.) Ashe. *Q. rubra* of many authors (see Ashe, *Proc. Soc. Am. Foresters*, **11**: 90, 1916). This variety is not separable from the typical form of the species on leaf characters alone.

48. *Q. ELLIPSOIDALIS* E. J. Hill. Owing to the similarity in leaf characters of this species, *Q. coccinea*, *Q. Shumardii*, and *Q. Shumardii* var. *Schneckii*, it was considered best to separate these species on habitat, bud characters, and distribution.

SOME ADVENTITIOUS PLANTS IN CONCORD,
MASSACHUSETTS.

RICHARD J. EATON

WHILE crossing a large sandy field overlooking the Sudbury River in Concord in June, 1934, my attention was attracted by an abundance of a shrubby *Hypericum*, *Pentstemon* *Digitalis* Nutt., several species of *Artemisia*, and numerous other strange plants too immature to recognize. Repeated visits during the next four months yielded a surprisingly long list of introduced species not previously reported from Concord nor, in some instances, from New England. Two species of *Artemisia* may prove to be new to the Gray's Manual range. The identifications were carefully checked at the Gray Herbarium. Mr. C. A. Weatherby kindly assisted in assigning provisional names to the *Artemisi*as.

In the following annotated list the dates given are those on which were collected the specimens now deposited in the herbarium of the New England Botanical Club. A single asterisk (*) indicates a species not previously reported from Massachusetts, and two (**) not previously reported from New England, in so far as the author can discover. For data concerning "extra-limital" distribution not available in the herbarium of the New England Botanical Club I am indebted to the following institutions: Gray Herbarium, New York Botanical Garden, and the Brooklyn Botanic Garden.

TRIODIA FLAVA (L.) Hitchc. September 20, 1934. Fairly abundant.

DIANTHUS ARMERIA L. Not previously reported from Concord. Scattered specimens observed.

LEPIDIUM CAMPESTRE (L.) R. Br. Abundant in a restricted area.

ARABIS GLABRA (L.) Bernh. Not previously reported in Concord and clearly introduced here. Scarce.

A. DRUMMONDI Gray. The typical pale-flowered form is indigenous on rocky talus in one or two localities in Concord. The present specimens rank and weedy, with prominent purplish flowers, drying to a deep purple. Mr. Milton Hopkins, a monographer of this genus, concurs in the determination but writes that the present plant is a purple-flowered extreme only met in his experience in collections from Texas. Apparently well established.

MELILOTUS OFFICINALIS (L.) Lam. August 19, 1934. Scarce.

***HYPERICUM DENSIFLORUM* Pursh. July 18, 1934. A single large plant in profuse flower and fruit. A southern species reaching New Jersey and Long Island.

H. PROLIFICUM L. July 18, 1934. Abundant. Rarely spontaneous in eastern Massachusetts and Connecticut, otherwise absent from New England.

ECHIUM VULGARE L. July 8, 1934. Scarce. Recently collected at one other station in Concord.

VERBENA STRICTA Vent. July 19, 1934. Well established. The third station in eastern Massachusetts. Rarely spontaneous in Connecticut. Otherwise absent from New England.

MONARDA MOLLIS L. July 18, 1934. Abundant. Considered sparingly indigenous in eastern Massachusetts, but doubtless adventive here.

**PYCNANTHEMUM PIOSUM* Nutt. August 6, 1934. Well established. Reported from a single Connecticut station. Otherwise absent from New England.

VERNONIA FASCICULATA Michx. September 20, 1934. Scarce but vigorous. A single collection from Medford, Massachusetts, in 1886. Otherwise absent from New England.

EUPATORIUM SEROTINUM Michx. September 9, 1934. Common. Apparently new to New England, except for a single plant collected at a nursery in North Abington, Massachusetts, in 1933 (Gray Herbarium).

GRINDELIA SQUARROSA (Pursh) Dunal. August 6, 1934. Abundant. Specimens seen from seven stations in Maine, Massachusetts, Rhode Island, and Connecticut.

ASTER NOVAE-ANGLIAE L. var. *ROSEUS* (Desf.) DC. September 20, 1934. Fairly common. Differs from the species in this vicinity in its tolerance of dry soil and in its frequent habit of growing in single stems rather than in clumps.

HELIANTHUS SCABERRIMUS Ell. August 13, 1934. A large patch. Specimens seen from seven scattered stations in Maine, Massachusetts, Rhode Island, and Connecticut.

HELENIUM NUDIFLORUM Nutt. August 6, 1934. Abundant. Occurs sparingly at two other stations in Concord and in three other towns in eastern Massachusetts. Scattered stations elsewhere in New England.

H AUTUMNALE L. September 9, 1934. Rather common. Formerly abundant in a wet meadow near Concord Village. Reported from a single station in Essex County, Massachusetts. Probably indigenous in Berkshire County, Massachusetts, and central and western Connecticut.

ARTEMISIA LUDOVICIANA L. July 8, 1934. Rather scarce. Upper surface of leaves more tomentose than typical material. Reported from a dozen stations in Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut.

***A. MEXICANA* Willd. August 11, 1934. Not scarce. Indigenous from Missouri southwestward. Single specimens seen from Franklin Lakes, New Jersey, and from Nashville, Tennessee, otherwise apparently unreported from east of the Mississippi River.

**A. GNAPHALODES* Nutt. August 6, 1934. Common. Reported from scattered stations from Quebec and New Brunswick southward to Delaware.

***A. TRIDENTATA* Nutt. September 20, 1934. Common. Fruiting plants scarce. Apparently the first report of occurrence east of the Great Plains, and new to Gray's Manual range.

A. ABSINTHIUM L. August 13, 1934. Common. A form with abnormally narrow leaf segments occurs sparingly and was collected on August 6, 1934. Occasional throughout New England.

A. FRIGIDA Willd. July 8, 1934. A single specimen in close bud, but determination probably correct. Reported from Worcester, Massachusetts, in 1918 and from one station in Connecticut, otherwise absent from New England.

CENTAUREA MACULOSA Lam. August 6, 1934. Scarce. Sparingly introduced at scattered stations throughout New England.

In all probability the foregoing list will prove to be an incomplete inventory of the waifs from the West and South which are finding a congenial habitat in Concord. The summer was very dry and much vegetation, particularly the grasses, failed to reach maturity.

Originally a large Indian camp site, more recently under constant cultivation, and for two or three years ending in 1929 rented to Mr. Jelle Roos, the well-known commerical bulb grower, this ten acre tract of light sandy loam overlying a deep bed of sand and gravel has lain fallow for the past five years. The ground was not seeded to grass by Mr. Roos when he quitted his tenancy, nor has the vegetation been mowed or burned since that time according to the owner. One of many gray birch seedlings which have come in was by ring-count 5 years old in 1934.

It is of more than casual interest to find such a concentration of well established immigrants from the West, several of which are distinctly rare in New England. One species in particular—the sage bush of the alkali deserts—is apparently new to New England, if not to the entire country east of the Great Plains. The latter plant certainly betrays no marked ability to establish itself beyond the borders of its natural range, and yet we find it in comparative abundance with occasional fruiting specimens in eastern Massachusetts growing in a supposedly siliceous soil so characteristic of the region.

In all likelihood, the seeds of all these plants were accidentally introduced in sheep manure by the last tenant.¹ Ecological conditions were obviously favorable for germination and subsequent development. Undisturbed by plow, scythe, or fire, they now form a con-

¹ Mr. Roos writes under date of March 1, 1935: "I can explain the collection of Western weeds you found there by the fact that I used an uncleaned sheep manure which I bought from a man who obtained it from woolen mills in Lowell or Lawrence. This sheep manure contained a large percentage of wool combings, in which the weed seeds could plainly be seen when I received it."

spicuous element of the vegetation. Even so, there may be some obscure factor operating at this particular site which is absent from a multitude of other fallow fields where there would appear to be an equally good chance to harbor a similar collection of well established western weeds. Farmers have been using sheep manure from the woolen mills for years. Seeds of *Artemisia tridentata*, for example, must have been scattered far and wide in this manner; and yet here apparently is the first recorded occurrence of this species in eastern North America.

I am not disinclined to suspect that the "obscure factor" may have some connection with the aboriginal tenants of the field. At first sight, this may seem far-fetched, and yet rotted clam shells still exist in sufficient quantities to justify the local name Clam Shell Bluff. Probably of no more than mere coincidence is the fact that with the exception of sporadic specimens of a few of the species, the introduced plants are concentrated on precisely that part of the field where arrow heads formerly were abundant. In other words, they are now growing in the *close* vicinity of the very spots where the Indians erected their wigwams, and practically nowhere else.

CAMBRIDGE, MASSACHUSETTS

NOTES ON *OEDOGONIUM* AND *BULBOCHAETE* IN THE
VICINITY OF WOODS HOLE, MASSACHUSETTS¹

CHIN-CHIH JAO

(Plate 407)

IT was hoped that the writer's paper on *Oedogonium* in the vicinity of Woods Hole, Massachusetts,² would be nearly complete for the region. Altogether, including both new and known forms, fifty-one species, varieties and forms were reported. During 1934, from June to August, the writer had an opportunity to continue his investigation of the freshwater algae in this region, with the result of finding some new plants of this genus, or unreported stations for fruiting *Oedogonia*, which were not included in the writer's first paper. These are listed in the first part of this paper. In the course of the studies on *Oedogonium*, a number of well fruited *Bulbochaetes* were identified. These plants are rather common around Woods Hole, but only a few species

¹ Papers from the Department of Botany and Herbarium of the University of Michigan, No. 505.

² *RHODORA*, Vol. 36, No. 426, P. 197-214, Pl. 286-288, June, 1934.

are represented in the writer's collections, of which *Bulbochaete Fuberac* Collins and *B. Brebissonii* Kuetzing are most common. The second part of this paper is a preliminary report dealing with *Bulbochaete* as collected at Woods Hole and vicinity, Barnstable County, Massachusetts, mostly in the summer seasons from 1932 to 1934.

The materials were mostly collected by the writer and Miss H. T. Croasdale; the writer wishes to thank her for her kindness in permitting the study of her samples. This study was made at the Marine Biological Laboratory, Woods Hole and in the Botanical Laboratories of the University of Michigan, under the direction of Professor Wm. R. Taylor, to whom the author is deeply grateful for help and valuable advice.

I. OEDOGONIUM

1. *OEDOGONIUM CONCATENATUM* (Hassall) Wittrock. "Beede's Oscillatoria Pond," North Falmouth, July 31, 1934 (*Croasdale*). Very abundant, attached to water grasses.

2. *OEDOGONIUM CRENULATOCOSTATUM* Wittrock f. *CYLINDRICUM* Hansgirg. Long Pond, Falmouth, 1929; "West Wood Pond," North Falmouth, Aug. 4, 1934 (*Croasdale*).

3. *OEDOGONIUM CRISPUM* (Hassall) Wittrock var. *GRACILESCENS* Wittrock. "Scar Spring," a small spring near the west shore of Naushon Island, June 18, 1934 (*Jao and Croasdale*); "Pasque J" Pond, Pasque Island, June 25, 1934 (*Jao*); Long Pond, Falmouth, 1929.

4. *OEDOGONIUM CRISPUM* Wittrock var. *URUGUAYENSE* Magnus & Wille. "Pasque K" Pond, Pasque Island, June 26, 1934 (*Jao*).

5. *OEDOGONIUM CROASDALEAE* Jao. "Endicott Hollow," Endicott Road, in Woods Hole, Aug. 8, 1934 (*Croasdale*).

6. *OEDOGONIUM CRYPTOSPORUM* Wittrock. "Scar Spring," Nauson Island, June 18, 1934 (*Jao and Croasdale*).

7. *OEDOGONIUM CRYPTOSPORUM* Wittrock var. *VULGARE* Wittrock. "Sheep Pen Pond," Nonamesset Island, June 18, 1934 (*Jao and Croasdale*).

8. *OEDOGONIUM ECHINOSPERMUM* Al. Braun. The local plants have dwarf males on or near the siphulcary cell, stipes 1- to 3-celled, lower stipes 10-13 μ diam., 25-32 μ long, upper stipes 9-12 μ diam., 19-27 μ long. Collected in a pond near South Yarmouth, July 21, 1932.

9. *OEDOGONIUM HIANS* Nordstedt & Hirn var. *megasporum*, var. nov. (FIGS. 1, 2). *Oedogonium dioicum*, *nannandrium*, *idioandrosporum*; oogoniis 1-7, subglobosis, operculatis circumscissione superiore apertis; oosporis globosis, raro subglobosis, transversum oogonia fere complentibus vel complentibus, membrana laevi et crassa; androsporangiis 1-3 (-?); cellulis siphulcariis tumidis; nannandribus subtiliter curvatis, in cellulis siphulcariis sedentibus;

antheridiis exterioribus; cellulis vegetativis subtiliter capitellatis; cellula basali tumida; cellula terminali obtusa.

Cell. veg.	11–19 μ diam.,	64–102 μ long.
Oogonia	45–55 μ diam.,	48–83 μ long.
Oosporae	44–48 μ diam.,	44–58 μ long.
Cell. suffult.	35–38 μ diam.,	64–74 μ long.
Androsporangia	19 μ diam.,	22–26 μ long.
Nannand. stipes	11–13 μ diam.,	39–45 μ long.
Antheridia	8–10 μ diam.,	6–8 μ long.

Dioecious, nannandrous, idioandrosporous; oogonia 1–7, sub-globose, operculate, division superior; oospore globose, rarely sub-globose, nearly filling or filling the oogonium transversely, spore-wall smooth and thick; androsporangia 1–3(–?); suffultory cell swollen; dwarf male slightly curved, attached to the suffultory cell; antheridia exterior; vegetative cells slightly capitellate; basal cell tumid; terminal cell obtuse.

Long Island Pond, Falmouth, July, 1934 (Croasdale). Filaments scattered among many other filamentous algae. Type in C. C. Jao collections and Herb. Univ. Mich., Woods Hole No. 136.

These plants are characterized by their nannandrous habit, superior operculum, smooth spore-wall, swollen suffultory cell, and a tendency toward capitellate vegetative cells, showing that they are related to *Oe. hians* Nordstedt & Hirn. They differ, however, chiefly in having an idioandrosporous habit, a greater size, frequently long seriate oogonial chains, and the oospore usually not quite filling the oogonium.

10. *OEDOGONIUM OELANDICUM* Wittrock & Hirn var. *NOVAE-ANGLIAE* Jao. "Pasque J" Pond, Pasque Island, June 25, 1934 (Jao); "Endicott Hollow," Endicott Road, in Woods Hole, Aug. 8, 1934 (Croasdale).

11. *OEDOGONIUM PLATYGYNUM* Wittrock. "Sheep Pen Pond," Nonamesset Island, June 10, 1934 (Jao and Croasdale); "Deer Pond," Nonamesset Island, July 2, 1934 (Croasdale).

12. *OEDOGONIUM PRATENSE* Transeau. "Sheep Pen Pond," Nonamesset Island, June 19, 1934 (Jao and Croasdale).

14. *OEDOGONIUM RETICULOCOSTATUM* Jao. "Sheep Pen Pond," Nonamesset Island, June 19, 1934 (Jao and Croasdale); "Deer Pond," Nonamesset Island, July 2, 1934 (Croasdale).

14. *Oedogonium suborbiculare*, sp. nov. (Figs. 3, 4). Oedogonium dioicum, macrandrium; oogoniis 1- vel 10-continuis, subglobosis vel subellipsoidali-globosis, poro superiore apertis; oosporis globosis, interdum subglobosis, oogonia non vel fere complentibus, membrana triplici: episporio et endosporio laevibus; mesosporio scrobiculato, scrobiculationibus plus minusve concentricis et diametro variantibus; cellulis suffultiis interdum tumidis parvis; antheridiis 1–3; spermatozoidiis binis, divisione horizontali; cellulis vegetativis plus

minusve capitellatis; cellula basali elongata; cellula terminali acuta, in filamentis feminis frequenter substitutione oogonii nulla; filamentis masculis elongatis, ex cellulis vegetativis multis constantibus.

Cell. veg. plantae fem.	22-32 μ diam.,	112-218 μ long.
Cell. veg. plantae masc.	19-22 μ diam.,	130-210 μ long.
Oogonia (cum prolongatione)	64-74 μ diam.,	77-114 μ long.
Oosporae	54-67 μ diam.,	54- 67 μ long.
Antheridia	16-18 μ diam.,	13- 16 μ long.
Cell. basales	25-32 μ diam.,	166-180 μ long.
Cell. suffultoriae	22-38 μ diam.,	118-200 μ long.

Dioecious, macrandrous; oogonia 1-10, subglobose or ellipsoid-globose, pore superior; oospore globose, sometimes subglobose, not filling or nearly filling the oogonium, spore-wall of three layers: the outer and inner smooth, the median layer scrobiculate; scrobiculations more or less concentrically arranged and varying in diameter; suffultory cell sometimes slightly enlarged; antheridia 1-3; sperms 2, arising by horizontal division; vegetative cells more or less capitellate; basal cell elongate; terminal cell usually becoming an oogonium on fertile female filaments, but if sterile, acute; male filaments elongate, of many vegetative cells.

Lily Pond, Hatchville, between North and East Falmouth, Aug. 4, 1934 (*Croasdale*). Plants growing on water-grasses in company with *Bulbochaete Nordstedtii* Wittrock, etc. Type in C. C. Jao collections and Herb. Univ. Mich., Woods Hole No. 130.

This new species is distinguished from *Oe. Tiffanii* Ackley by the oogonium having a diameter always less than the length and by the larger vegetative cells, which are more or less capitellate in form. It also shows some characteristics of *Oe. scrobiculatum* Wittrock and *Oe. verrucosum* Hallas, but differs from the first chiefly in having a scrobiculate median spore-wall, from the second in having much better developed male filaments, not restricted to a holdfast cell and a few antheridial cells, and from both in having all cells of greater dimensions and vegetative cells more or less capitellate. The terminal oogonium of this new species generally extends into a long, acute process. The length of oogonia listed above includes the processes. If just the oogonia proper are considered, their length is 77-100 μ .

15. *OEDOGONIUM UNDULATUM* (Brebisson) Al. Braun f. *SENEGALENSE* (Nordstedt) Hirn (subforma). "Deer Pond," Nonamesset Island, July 2, 1934 (*Croasdale*).

II. BULBOCHAETE

1. *BULBOCHAETE BREBISSONII* Kuetzing. Furber Pond, Naushon Island, July 7, 1933 (Jao); "Wall Pond," Nonamesset Island, July 5 and 17, 1933 (Jao and *Croasdale*); Freshwater Pond, Nobska, Woods Hole, July 21, 1933 (Jao).

2. *BULBOCHAETE ELATIOR* Pringsheim. "Wood Pond," Ganset Road, in Woods Hole, June 23, 1933 (*Jao*).

3. *BULBOCHAETE FURBERAE* Collins. "Woods Pond," Ganset Road, in Woods Hole, June 23, 1933; Freshwater Pond, Nobska, Woods Hole, July 21, 1933 (*Jao*); "Wall Pond," Nonamesset Island, July 5, 1933 (*Jao and Croasdale*); Furber Pond, Naushon Island, July 7, 1933 (*Jao*); "Harper Pond," Whitman Road, Woods Hole, Aug. 27, 1933 (*Jao*).

4. *BULBOCHAETE INTERMEDIA* De Bary. "Sheep Pond," Cuttyhunk Island, 1922 (*Taylor*); July 27, 1933 (*Jao*).

5. *BULBOCHAETE INTERMEDIA* De Bary var. *DEPRESSA* Wittrock. "Sheep Pen Pond," Nonamesset Island, July 5, 1931 (*Croasdale*).

6. *BULBOCHAETE MIRABILIS* Wittrock. "On *Fontinalis* in a pond, Cuttyhunk Island, Gosnold, Massachusetts, July 11, 1907, in company with *B. intermedia* De Bary." *Phycotheca Boreali-Americana*, No. 1431.

7. *BULBOCHAETE NORDSTEDTII* Wittrock. Lily Pond, Hatchville, between North and East Falmouth, Aug. 4, 1934 (*Croasdale*).

8. *BULBOCHAETE NORDSTEDTII* Wittrock f. *SUBERECTA* Collins. Fawn Pond, Nonamesset Island, June 18, 1933 (*Croasdale*).

9. *Bulbochaete praereticulata*, sp. nov. (FIGS. 5-7). *Bulbochaete* dioica, nannandria, idioandrosporous; oogonia depressed-globose or rarely depressed obovoid-globose, patent, below terminal seta; division of suffultory cell median; outer wall of the spore reticulate-scorbiculate; androsporangia 1-7; dwarf males shorter than the oogonia, developed on oogonia or on suffultory cells; antheridia interior; stipe about twice as long as the antheridium, curved; vegetative cells, except the basal cells, oogonia and androsporangia spirally granulate.

Cell. veg.	16-26 (-29) μ diam.,	48-93 μ long.
Oogonia	54-58 μ diam.,	41-54 μ long.
Oosporae	52-56 μ diam.,	40-52 μ long.
Androsporangia	16-19 μ diam.,	6-10 μ long.
Nannand. stipes	9-10 μ diam.,	32 μ long.
Antheridia	9-10 μ diam.,	13-16 μ long.

Dioecious, nannandrous, idioandrosporous; oogonia depressed-globose or rarely depressed obovoid-globose, patent, below terminal seta; division of suffultory cell median; outer wall of the spore reticulate-scorbiculate; androsporangia 1-7; dwarf males shorter than the oogonia, developed on oogonia or on suffultory cells; antheridia interior; stipe about twice as long as the antheridium, curved; vegetative cells, except the basal cells, oogonia and androsporangia spirally granulate.

Shanks Pond, Falmouth, Aug. 4, 1934 (*Croasdale*). Type in C. C. Jao collections and Herb. Univ. Mich., Woods Hole No. 133.

Of the known species of this genus, only *Bulbochaete gigantea* Pringsheim has the reticulate outer spore-wall. This new species

has some similar characteristics, but differs distinctly in having acutely granulate vegetative cells, androsporangia and oogonia, and in the smaller dimensions of all parts.

10. *BULBOCHAETE PYGMAEA* Pringsheim & Wittrock var. *erecta*, var. nov. (FIGS. 8, 9). *Bulbochaete dioica*, *nannandria*, *gynandrospora*; filamentis abbreviatis, plerumque longitudine minus quam 10-cellularibus, simplicibus vel breviter ramosis, ramis 1- vel 2-cellularibus; oogoniis ellipsoideis, erectis, plerumque proximis ad cellulam basalem rarius terminalibus vel patentibus sub cellulis vegetativis vel setis; episporio longitudinaliter costato, costis fere 22, denticulatis, dentibus interse transverse costulatis; cellulis suffultioriis indivisis; androsporangis sparsis, 1-2-cellularibus; nannandribus prope oogonia sedentibus; antheridiis exterioribus.

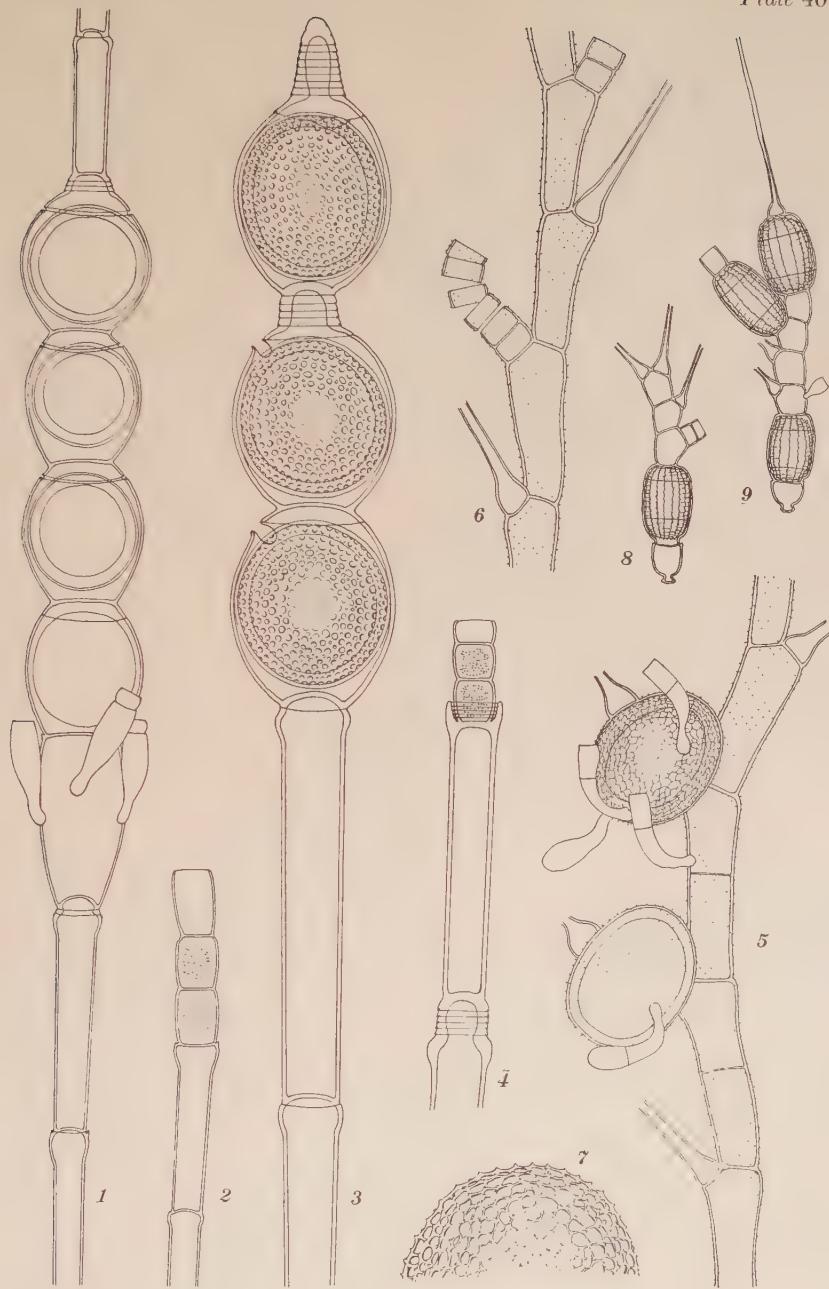
Cell. veg.	13-16 μ diam.,	10-16 μ long.
Oogonia	19-22 μ diam.,	29-38 μ long.
Oosporae	18-21 μ diam.,	28-35 μ long.
Androsporangia	10 μ diam.,	3 μ long.
Nannand. stipes	11 μ diam.,	16 μ long.
Cell. basales	13-16 μ diam.,	19-22 μ long.

Dioecious, nannandrous, gynandrosporous; filament short, usually less than ten cells long, unbranched or with 1- or 2-celled branches; oogonia ellipsoid, erect, usually next to the basal cell, very rarely terminal or patent below vegetative cells or setae; outer spore-wall longitudinally ribbed, ribs about 22 in number, dentate, the teeth united to each other by transverse ridges; suffultory cell without division; androsporangia scattered, 1-2; dwarf males near the oogonium; antheridium exterior.

Lily Pond, Hatchville, between North and East Falmouth, Aug. 4, 1934 (*Croasdale*). Epiphyte on *Bulbochaete Nordstedtii* Wittrock. Type in C. C. Jao collections and Her. Univ. Mich., Woods Hole No. 130.

This variety differs from the typical form in having the oogonia usually erect, in the smaller dimensions and in its very short filaments unbranched or with few very short branches. The author has compared this variety with typical *B. pygmaea* in F. S. Collins' specimens (*Phycotheca Boreali-Americanana* No. 1683), and it appears quite different, especially in the position of the oogonia and the habit of the whole plant, for *B. pygmaea* has the oogonia regularly patent and the plant is longer and with more numerous branches.

11. *BULBOCHAETE REPANDA* Wittrock. Long Pond, Falmouth, July 15, 1900, *Phycotheca Boreali-Americanana*, No. 814; "Sheep Pen Pond," Nonamesset Island, July 5, 1931 (*Croasdale*); Freshwater Pond, Nobska, Woods Hole, July 21, 1933 (Jao).



Jao del.

Figs. 1 and 2, *OEDOGONIUM HIANS* var. *MEGASPORUM*; figs. 3 and 4, *O. SUBORBITICULARE*; figs. 5-7, *BULBOCHAETE PRAERETICULATA*; figs. 8 and 9, *B. PYGMAEA* var. *ERECTA*; figs. 1-6 and 8 and 9, $\times 303$; fig. 7, $\times 652$

EXPLANATION OF PLATE 407

FIGS. 1, 2. *OEDOGNIUM HIANS* Nordstedt & Hirn var. *MEGASPORUM* Jao, var. nov. FIG. 1, part of the female filament, with three mature oogonia and one young oogonium and three dwarf males on the swollen suffultory cell; FIG. 2, part of the androsporangial plant, with three androsporangia.

FIGS. 3, 4. *OEDOGNIUM SUBORBICULARE* Jao, sp. nov. FIG. 3, tip of the female filament, with three mature oogonia; FIG. 4, part of the male filament, showing three antheridia, two of which each contain two sperms formed by a transverse division.

FIGS. 5-7. *BULBOCHAETE PRAERETICULATA* Jao, sp. nov. FIG. 5, part of the female filament, with mature (upper) and young (lower) oogonia, and the dwarf males on both the suffultory cell and oogonia; FIG. 6, part of the androsporangial plant, showing two series of androsporangia; FIG. 7, part of the oospore, showing the reticulate outer spore-wall.

FIGS. 8, 9. *BULBOCHAETE PYGMAEA* Wittrock var. *ERECTA* Jao, var. nov. FIG. 8, a typical plant, the unbranched filament with an oogonium next to the basal cell and two androsporangia; FIG. 9, a less common plant, showing erect and patent oogonia and a dwarf male sitting on the vegetative cell near the oogonium.

FIGURE 7 was made with the camera lucida at a magnification of 1550 diameters, the others at 720 diameters, and they are reduced in reproduction to 652 diam. and 303 diam. respectively.

SOME FORMS IN THE ALISMACEAE

M. L. FERNALD

ECHINODORUS CORDIFOLIUS (L.) Griseb., forma *lanceolatus* (Engelm.), comb. nov. *E. rostratus*, var. *lanceolatus* Engelm. in Mackenz. & Bush, Man. Fl. Jackson Co. Mo. 10 (1902) in syn. *E. cordifolius*, var. *lanceolatus* (Engelm.) Mackenz. & Bush, l. c. (1902).

With no clearly defined range and differing only in its small and narrow leaves this is better treated as a form.

LOPHOTOCARPUS SONGIOSUS (Engelm.) J. G. Sm., forma *laminatus*, n. f., foliis laminatis, laminis lanceolatis vel ovatis elobatis vel sagittatis.—Massachusetts to Virginia. TYPE: muddy places, Delaware City, DELAWARE, September 18, 1894, *A. Commons*, in Gray Herb.

LOPHOTOCARPUS CALYCINUS (Engelm.) J. G. Sm., forma *maximus* (Engelm.), comb. nov. *Sagittaria calycina*, var. *maxima* Engelm. in Torr. Bot. Mex. Bound. Surv. 212 (1858). *S. calycinus*, var. *grandis* Engelm. in Gray, Man. ed. 5: 493, 494 (1867). *L. calycinus*, var. *maximus* (Engelm.) Robinson in RHODORA, x. 31. (1908).

This and the next seem to be a very robust and a very depauperate form rather than true varieties.

LOPHOTOCARPUS CALYCINUS (Engelm.) J. G. Sm., forma *depauperatus* (Engelm.), comb. nov. *Sagittaria calycina*, var. *depauperata* Engelm. in J. G. Sm. Lophot. U. S. 4, in syn. (1899). *L. depauperatus* (Engelm.) J. G. Sm. l. c. (1899).

SAGITTARIA RIGIDA Pursh, forma *fluitans* (Engelm.), comb. nov. *S. heterophylla*, var. *fluitans* Engelm. in Gray, Man. ed. 2: 439 (1856).

S. RIGIDA, forma **elliptica** (Engelm.), comb. nov. *S. heterophylla*, var. *elliptica* Engelm. l. c. (1856).

SAGITTARIA ENGELMANNIANA J. G. Sm.; forma **dilatata**, n. f., a forma typica recedit laminis ovatis vel deltoideis.—Range of the species, much less common. The following belong here. MASSACHUSETTS: peaty margin of Goodenough Pond, Yarmouth, September 19, 1913, *Fernald & Long* no. 8466 (TYPE in herb. N. E. Bot. Club). RHODE ISLAND: boggy pond-margin, northeast of Woodville, August 30, 1919, *Fernald & Collins*; boggy margin of Tippecan Pond, Exeter, September 22, 1920, *Graves & Woodward*. CONNECTICUT: bog south of Poquonoc Lake, Groton, September 14, 1905, *Graves*. NEW YORK: swampy pine-barren thicket, Ronkonkoma, Long Isl., September 25, 1922, *W. C. Ferguson*. NEW JERSEY: quagmire near Deer Pond, Atco, September 26, 1921, *Meredith*.

SAGITTARIA CUNEATA Sheldon, forma **hemicycla**, n. f., a forma typica recedit foliis ovatis apice rotundatis.—Occasional through the range; TYPE: rocky tidal shore of St. Lawrence River, St. Augustin, Co. Portneuf, Quebec, August 7, 1923, *Svenson & Fassett*, no. 1063 (Gray Herb.).

S. CUNEATA, forma **equiloba**, n. f., a forma typica recedit lobis basilaribus plus minusve divergentibus lobum terminalem aequantibus vel subaequantibus acutis.—Occasional throughout the range; TYPE: Isle Royale, Michigan, August 25, 1910, *Cooper*, no. 290 (Gray Herb.).

ROGERS'S "TREE FLOWERS OF FOREST, PARK, AND STREET."¹—Professor Rogers has produced a new kind of tree book. As a compendium of information, it is no rival of such works as Hough's, nor does it pretend to be. But it does fill a neglected field—that of adequate, large-scale, photographic illustration of the tiny and inconspicuous, but often morphologically significant, flowers of many woody species. The only precedent for it which comes to mind—and that a partial one—is to be found in the views of enlarged sori in C. E. Waters's "Ferns." Prof. Rogers's photographs, done by a special technique of his devising, attracted much favorable comment when they were exhibited at various botanical institutions some two years ago. They are now made available to the public, in fine half-tone reproduction, in the present exceptionally well printed and handsome volume.

About 85 species are illustrated. Rarely, as in the elm samara shown, the effect is rather foggy; and one could wish that the dissecting-needles on which many flowers are very obviously impaled might have been painted out of the negatives. But for the most part the plates are in every way admirable. Each is accompanied by a few paragraphs of informal descriptive and explanatory text, set in a small block in the middle of the page. The wide margins thus left are utilized for silhouette drawings of some distinctive feature of the species concerned—fruit, leaves, leaf-scars, buds and the like. These are further supplemented by

¹ Rogers, Walter E. Tree Flowers of Forest, Park, and Street. Published by the Author, Appleton, Wisconsin. 1935. (13) + 500 pp. Illustrated from photographs by the author and drawings by Olga A. Smith.

habit-silhouettes of the whole plant, in the case of deciduous-leaved species in winter condition. These fulfill well and accurately and with a vividness and esthetic appeal which photographs could hardly achieve, their stated purpose of portraying the characteristic architecture of species—least successfully, perhaps, in the conifers.

It is hard to say whether this book should interest the artist or the botanist more. Certainly the former can get from it many hints as to design; and for the latter, the plates show the morphology of many flowers so clearly and fully as to be a real and welcome addition to his working material.—C. A. W.

A NEW COLUMBINE FROM THE EDWARDS PLATEAU OF TEXAS

V. L. CORY

UP till the month of May, 1934, the writer was unaware that a native columbine could be found on the Edwards Plateau of Texas. When found it was in a place not readily accessible to goats and sheep, both of which are pastured in these timbered hills along the Frio River, or to deer that even to the present time range there in more or less abundance. This columbine is rare, for but three plants were noted in the locality of collection, which was on a shelving slope of limestone at the base of a limestone cliff on the Frio River at some distance above the town of Leakey in Real County. These plants were growing in small, somewhat circular, relatively deep holes or pockets in solid limestone, which is kept more or less wet by seepy springs. One plant was left untouched, and it was not possible to get the roots of the other two plants out from their rocky pits. The plants should continue to grow and reproduce and escape observation for the most part, as heretofore.

AQUILEGIA phoenicantha, sp. nov., perennis herbacea, rhizomate lignoso; caule striato quadrangulato inferne sparse piloso superne glabro; foliis circumscriptione orbicularibus diametro 4–5 cm. triter-natis supra viridibus infra glaucis, foliolis cuneato-ovatis profunde trilobatis lacinias leviter lobatis apice rotundatis truncatis, venis prominentibus; pedunculis gracilibus 6–8 mm. longis; floribus solitariis erectis, sepalis 10–13 mm. longis elliptico-ovatis abrupte acuminatis rubescenti-purpureis unguiculatis, ungi 3 mm. longo, calcare recto rubescenti-purpureo 22–25 mm. longo anguste infundibuliformi, infra labellum 6 mm. diametro supra nectarium 1 mm.; petalorum labello 5–6 mm. longo intus flavo, extus apicem truncatum vel leviter rotundatum versus flavo alibi rubescenti-purpureo; staminibus multis plerumque ultra 10 mm. longis petala valde super-antibus; folliculis erectis 15–17 mm. longis, in caudam gracillimam

glabram 1 cm. vel ultra maturitate recurvatum sensim angustatis; seminibus multis circa 1.5 mm. longis 1 mm. latis cymbiformibus vel triangulatis dorso rotundatis laevibus.

AQUILEGIA phoenicantha, new species. Plant herbaceous, perennial from a woody root; stem striate, 4-angled, sparsely pilose below, glabrous above; leaves triternately compound, orbicular in outline, 4-5 cm. in diameter, prominently veined, bright green above and glaucous below; leaflets cuneate-ovate, deeply 3-lobed, segments shallowly lobed, the apices rounded or truncate; flowers solitary, erect, on slender peduncles 6-8 mm. long; sepals 10-13 mm. long, elliptic-ovate, abruptly acuminate, reddish-purple, with a claw 3 mm. long; spurs straight, prominently knobbed at the end, reddish-purple, tapering from 1 mm. broad above the knob to 6 mm. broad below the projecting lip, 22-25 mm. long; projecting lip of petals 5-6 mm. long, yellow on the inside and yellow at the apex outside but changing to reddish-purple at 3 mm. below the apex, which is truncate or slightly rounded; stamens numerous, mostly exceeding 10 mm. in height, and exserted above the petals to as much as 10 mm.; follicles erect, 15-17 mm. long, tapering gradually into a very slender, glabrous tail, which is 1 cm. or more long and mostly recurved at maturity; seeds numerous, about 1.5 mm. long and 1 mm. broad, boat-shaped or 3-angled and rounded on the back, smooth.

Specimen No. 8504 is designated as the **TYPE**, and the same is deposited at the Gray Herbarium. It was collected on the Frio River in Real County, May 11, 1934. It shows both the flower and the fruit. The other native columbines of Texas occur in the mountains some 200 miles to the west.

TEXAS AGRICULTURAL EXPERIMENT STATION,
Sonora, Texas.

A SMOOTH-HUSKED HAZEL.—The Beaked Hazel, *Corylus cornuta* Marsh. (*C. rostrata* Ait.) furnishes one of the best of wild nuts, comparable with the Old World filbert. It has a great disadvantage for the nut-gatherer in its prolonged and excessively bristly involucre. In late August, 1915, Mr. H. B. Jackson and I found a considerable thicket, heavily fruited, with the involucres essentially glabrous. This form, which, crossed with the filbert, might yield a desirable crop for northern latitudes, may be called

CORYLUS CORNUTA Marsh., forma **inermis**, forma nova, involueris glabris vel vix setulosis.—QUEBEC: abundant in border of woods, East Broughton, August 28, 1915, *Fernald & Jackson*, no. 12,073 (TYPE in Gray Herb.)—M. L. FERNALD.

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